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Haddock Bionomics II

The Growth of Haddock in the North Sea and at Faroe

By RODNEY JONES, B.Sc.
Marine Laboratory, Aberdeen

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The Growth of Haddock in the North Sea and at Faroe

By RODNEY JONES, B.Sc.
Marine Laboratory, Aberdeen — January, 1962

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CONTENTS

	Page
INTRODUCTION	3
NORTH SEA HADDOCK	3
Subdivision into areas	3
Treatment of data	4
Comparison of areas	4
Comparison of years	6
Growth curves	10
FAROE HADDOCK	11
Subdivision into areas	11
Comparison of areas	11
Comparison of years	13
Market data	15
Growth curves	17
Seasonal variations in growth	17
SEX DIFFERENCES IN LENGTH	17
SUMMARY	18
REFERENCES	19

Haddock Bionomics II

The Growth of the Haddock in the North Sea and at Faroe

INTRODUCTION

The growth of the haddock in the north-east Atlantic has been studied by Thompson (1922, 1924, 5, 1928, 1929), Bowman (1932), Raitt (1939), Anderson (1938), Hickling (1947), Parrish (1949, 6), Parrish and Main (1950), Jones (1951–1961) and Jones and Main (1951–1958) and in the north- Atlantic by Needler (1931), Schuck (1948) and Graham (1952). These authors showed that the yth rates of haddock differ between localities and fluctuate seasonally, that the annual growth ements decrease with age and that there is a variation in size amongst the individuals of the same taken at the same place. Annual fluctuations in the growth of North Sea haddock were studied by t (1939), who showed that there was an increase in the growth rate during the period from 1930 936. Since 1949, size distribution data of North Sea haddock have been published periodically in *les Biologiques*.

This report presents a summary of the extensive growth data collected by Scottish research vessels 1926 to 1959 and of measurement data collected on Aberdeen fish market from 1950 to 1959. It is ntinuation of the work of Thompson and Raitt and sets out to show how haddock sizes throughout North Sea have varied during the past 30 years.

NORTH SEA HADDOCK

DIVISION INTO AREAS

Thompson (1929) subdivided the North Sea into a number of areas according to the different growth s of haddock, the main areas being shown in Fig. 1. His results show that growth rate can be related

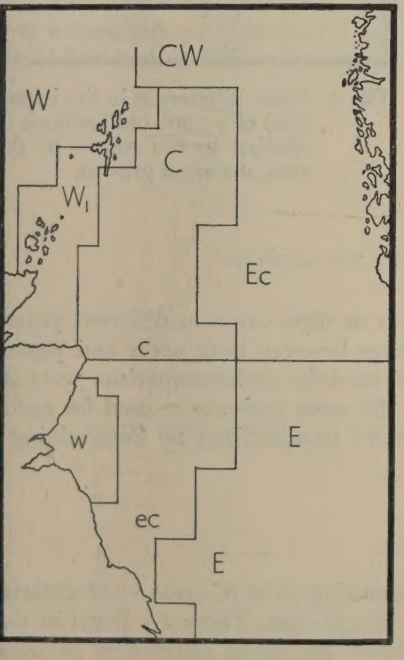

Fig. 1 Thompson's (1929) subdivision of the North Sea into different growth areas.

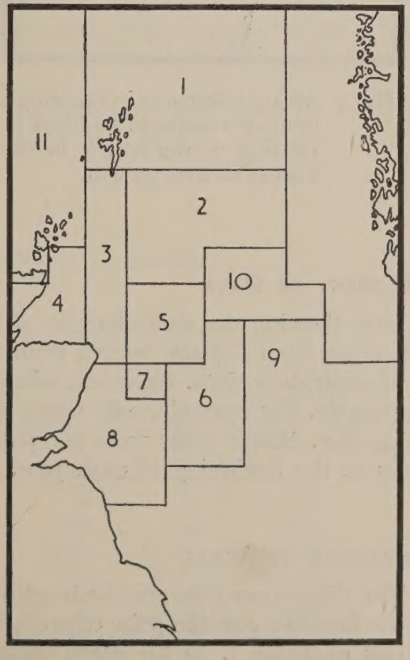

Fig. 2 Chart, showing the subdivision of the North Sea into areas.

closely to depth of water, and a method of subdivision, based partly on Thompson's areas and part on depth, has been adopted for this report. Fig. 2 shows the eleven areas used in this investigation. Are 9 and 10 are roughly equivalent to Thompson's areas of fastest growth (E), and 4 and 11 coinci roughly with his area of intermediate growth (W).

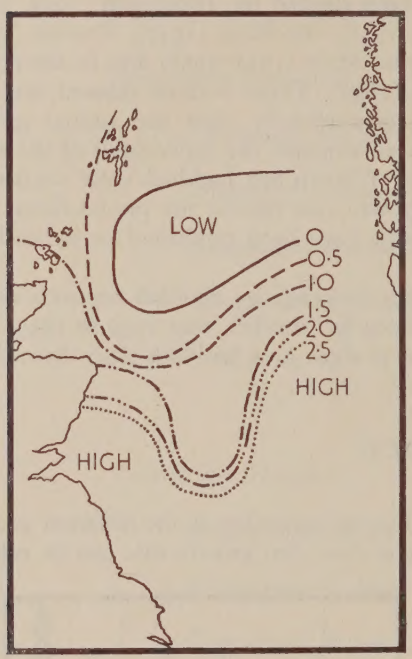

Fig. 3 Mean differences in the length (cm) of 1-year-old haddock in relation to the length in the area of slowest growth.

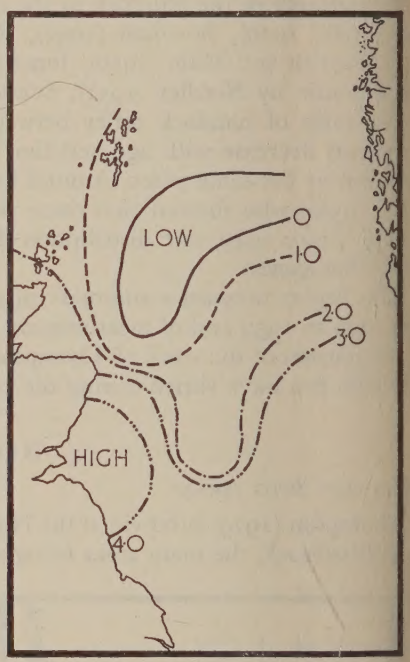

Fig. 4 Mean differences in the length (cm) of 3-years-old haddock in relation to the length in the area of slowest growth.

Treatment of Data

Data showing the mean lengths of haddock of different ages in these areas in different years ha been taken from *Explorer* records from 1926 to 1957. Comparisons between both areas and years we made using these data. Care was taken to ensure that the data used for each comparison were strict comparable. For example, only mean lengths determined from the same cruise were used for each ar comparison. Before years were compared, the mean lengths were standardized by determining th values at the beginning of each year.

Comparison of Areas

The differences between the lengths of haddock from neighbouring pairs of areas were determine Of the fifty-five possible pairs of areas fifteen were selected for comparison. These are listed in the fi column of Table I. In the other columns of this table are shown the mean differences between t lengths of haddock taken from these areas, the results representing averages for the period from 1926 1957. For example, a comparison of area 1 with area 2 showed that one-year-old fish were 0·44 c larger in area 1. O-group fish, on the other hand, were 0·20 cm smaller.

TABLE I

MEAN DIFFERENCES (CM) BETWEEN THE LENGTHS OF HADDOCK TAKEN FROM DIFFERENT AREAS 1926-1957

Area	Age					
	0+	1+	2+	3+	4+	5+
1 minus 2 . .	−0·20	0·44	1·08	0·78	1·13	1·35
1 „ 3 . .	−0·01	0·23	0·48	−0·13	−0·52	0·32
1 „ 11 . .	0·54	−0·26	−0·61	−0·97	−1·30	−1·31
2 „ 3 . .	−0·18	−0·41	−0·61	−0·86	−1·03	−0·62
2 „ 5 . .	0·18	−0·27	−0·15	−0·16	0·15	−0·18
2 „ 10 . .	0·55	−0·52	−0·83	−1·31	−1·08	−2·58
3 „ 5 . .	0·09	0·13	0·39	0·90	1·12	1·43
3 „ 4 . .	−0·23	−1·06	−1·36	−1·91	−1·48	−0·86
3 „ 11 . .	0·54	−0·37	−1·11	−1·10	−1·61	−1·39
5 „ 10 . .	−0·14	−0·15	−1·11	−1·03	−1·47	−2·20
5 „ 7 . .	−0·15	−1·51	−1·72	−3·07	−4·12	−2·06
5 „ 6 . .	−0·91	−0·90	−1·13	−1·11	−1·02	−0·25
7 „ 8 . .	−0·69	−0·96	−1·48	−1·47	−2·37	−3·49
6 „ 7 . .	0·77	−0·48	−0·92	−1·43	−1·96	−1·70
6 „ 9 . .	−0·37	−1·41	−1·50	−2·59	−3·08	−3·64

The data in Table I can be used to arrive at estimates of the mean lengths in each area relative to e in any other area. For this purpose, area 2, which appears to be the area of slowest growth, has been d as a standard, and the results are shown for all ages in Table II and for the one-, three- and five-rs-old haddock in Figs. 3, 4 and 5 respectively.

TABLE II

SHOWING THE MEAN LENGTHS (CM) OF NORTH SEA HADDOCK RELATIVE TO THOSE IN AREA 2

Area	Age					
	0+	1+	2+	3+	4+	5+
1	−0·20	0·44	1·08	0·78	1·13	1·35
2	0	0	0	0	0	0
3	0	0·31	0·60	0·88	1·34	0·82
4	0·23	1·37	1·96	2·79	2·82	1·68
5	−0·13	0·22	0·18	0·07	0·04	−0·22
6	0·78	1·12	1·31	1·18	1·06	0·03
7	0·02	1·66	2·06	2·88	3·59	1·78
8	0·71	2·62	3·54	4·35	5·96	5·27
9	1·15	2·53	2·81	3·77	4·14	3·67
10	−0·28	0·44	1·06	1·20	1·30	2·28
11	−0·64	0·69	1·70	1·86	2·69	2·44

It is seen that the largest haddock in an age group are found off the east coast of Scotland and in th neighbourhood of the Great Fisher Bank. Comparison of the largest with the smallest haddock show that at age one year the difference is more than 2·5 cm. At age three years the difference is about 4 cm and at age five years it is more than 5 cm. These results agree quite well with those of Thompson (1929) except that Thompson's largest fish were in the south-eastern part of the North Sea as well as in th neighbourhood of the Great Fisher Bank. However, sampling since 1947 has shown that the mea haddock density in the south-eastern North Sea has been very low, so that the haddock off the Scottis east coast became more noticeably the largest in the North Sea.

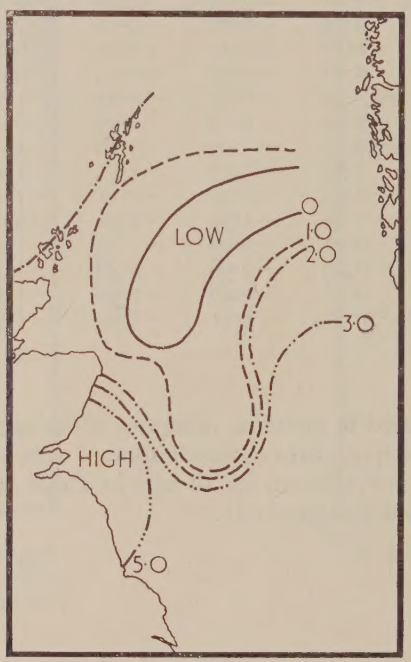

Fig. 5 Mean differences in the length (cm) of 5-years-old haddock in relation to the length in the area of slowest growth.

Variations in the size of O-group haddock throughout the North Sea is less marked than among th older fish. It is apparent, though, that O-group haddock from the south-westerly areas, 4, 6, 7, 8 and 9 are larger than those from the northern and central areas, 1, 2, 3, 5, 10 and 11 (Table II). This agree closely with the findings of Thompson (1929).

It appears, therefore, that haddock off the Scottish east coast grow faster throughout their lives tha those elsewhere in the northern North Sea.

Comparison of Years

In Table III are shown the mean lengths of haddock in areas 2 and 8, the slowest and fastest growt areas respectively, from 1926 to 1957. These values are also plotted in Figs. 6 and 7.

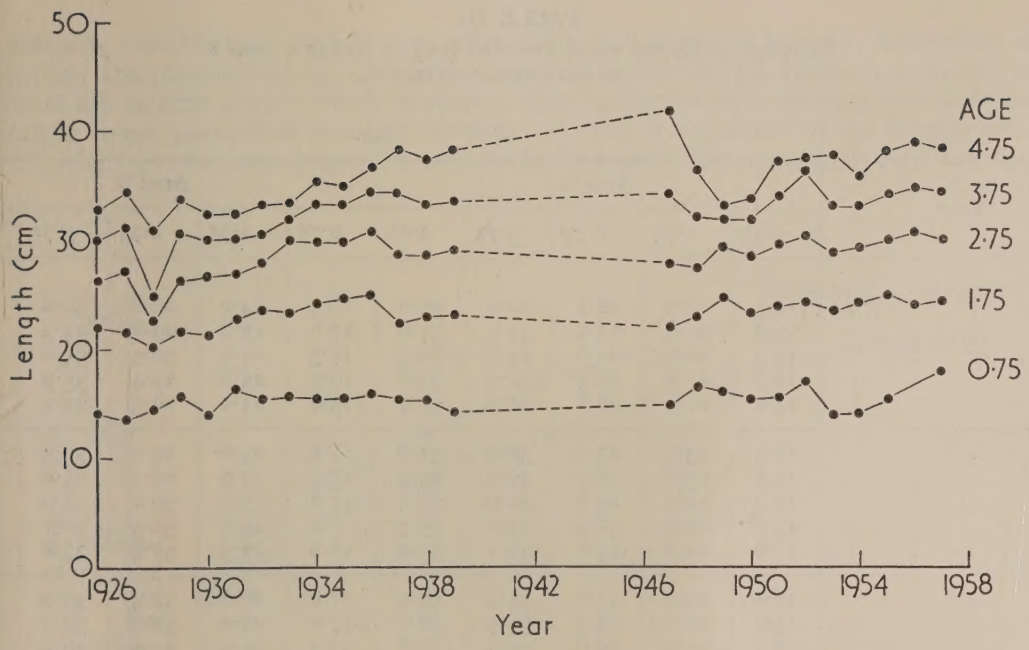

Fig. 6 Annual variations in haddock mean lengths (cm) in area 2, the area of slowest growth.

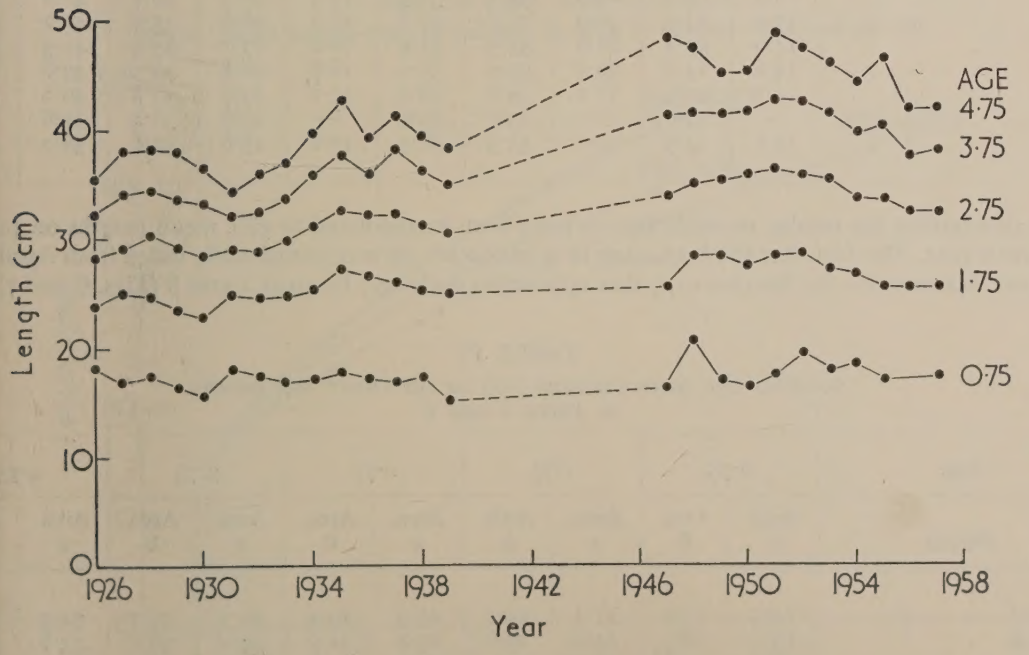

Fig. 7 Annual variations in haddock mean lengths (cm) in area 8, the area of fastest growth.

TABLE III

SHOWING HADDOCK MEAN LENGTHS (CM) IN AREAS 2 AND 8 IN SUCCESSIVE YEARS

Year	Age									
	Area 2					Area 8				
	0·75	1·75	2·75	3·75	4·75	0·75	1·75	2·75	3·75	4·75
1926	14·4	22·0	26·4	30·0	33·0	18·3	24·0	28·8	32·6	36·0
1927	13·8	21·6	27·2	31·5	34·6	17·0	25·1	29·6	34·3	38·6
8	14·3	20·2	22·6	24·8	30·7	17·5	24·9	30·5	34·6	38·5
9	15·7	21·8	26·5	30·3	33·8	16·5	23·8	29·4	33·9	38·3
1930	14·2	21·2	26·8	29·9	32·4	15·8	23·0	28·5	33·2	36·7
1	16·5	23·0	27·0	30·0	32·6	18·3	25·0	29·2	32·2	34·7
2	15·2	23·8	28·0	30·3	33·3	17·3	24·9	29·1	33·0	36·5
3	15·7	23·5	29·9	32·0	33·5	17·2	25·1	30·1	34·0	37·1
4	15·6	24·4	30·0	33·2	35·3	17·2	25·5	31·5	36·1	39·9
5	15·8	24·9	29·8	33·1	35·0	18·0	27·3	32·8	37·8	42·9
6	16·0	25·0	31·0	34·4	36·9	17·6	26·8	32·3	36·0	39·4
7	15·4	22·5	28·8	34·3	38·2	17·1	26·0	32·8	38·3	41·8
8	15·3	23·0	28·6	33·5	37·8	17·3	25·5	31·4	36·2	39·7
1939	14·4	23·5	29·2	33·6	38·4	15·4	25·1	30·9	35·1	38·6
1947	15·0	22·0	27·8	34·5	42·0	16·4	25·7	34·0	41·6	48·6
8	16·5	23·0	27·6	32·3	36·5	20·3	28·2	35·0	41·4	47·5
9	16·0	24·8	29·7	32·0	33·5	17·0	28·4	35·7	41·3	45·0
50	15·5	23·3	28·8	32·1	34·0	16·1	27·5	36·0	41·7	45·3
1	15·4	24·1	29·8	34·2	37·3	17·7	28·7	36·2	42·8	48·8
2	17·0	24·5	30·8	36·7	37·6	19·3	28·8	35·9	42·2	47·4
3	14·0	23·4	28·8	33·5	37·9	18·0	27·1	35·4	41·3	46·0
4	14·2	24·2	29·3	33·2	36·0	18·8	26·8	33·5	39·6	44·7
5	15·7	25·1	30·2	34·6	38·5	17·0	25·5	33·4	40·1	46·5
6	—	24·0	31·0	35·0	39·0	—	25·6	32·4	37·6	42·0
1957	17·8	24·5	30·0	34·5	38·5	17·2	25·8	32·6	38·0	42·0

To standardize the results, monthly figures have been extrapolated to give mean lengths on January 1st of each year. The fact that the beginning of a haddock's life is conventionally dated from April 1st of each year, accounts for the fraction 0·75 that appears in each age. In areas 2 and 8 (Figs. 6 and 7), sizes

TABLE IV

SHOWING THE MEAN LENGTHS (CM) OF DIFFERENT AGE GROUPS IN AREAS 2 AND 8

Age	0·75		1·75		2·75		3·75		4·75	
Period	Area 2	Area 8	Area 2	Area 8	Area 2	Area 8	Area 2	Area 8	Area 2	Area 8
1926–30	14·5	17·0	21·4	24·2	25·9	29·4	29·3	33·7	32·9	37·6
1936–39	15·3	16·9	23·5	25·8	29·4	31·9	34·0	36·4	37·8	39·9
1947–57	15·7	17·8	23·9	27·1	29·4	34·6	33·9	40·7	37·3	45·8

emained fairly constant from 1926 to 1930, after which they tended to increase, particularly amongst he older fish. This phenomenon has already been reported by Raitt (1939). However, from 1947 onwards he sizes of fish in area 2 were mainly similar to those before the war, whereas in area 8 they were ubstantially larger, particularly amongst the older fish. This is also shown by the summarised data in Table IV, which give the mean lengths for each age in the periods 1926-1930, 1936-1939, and 1947-1957.

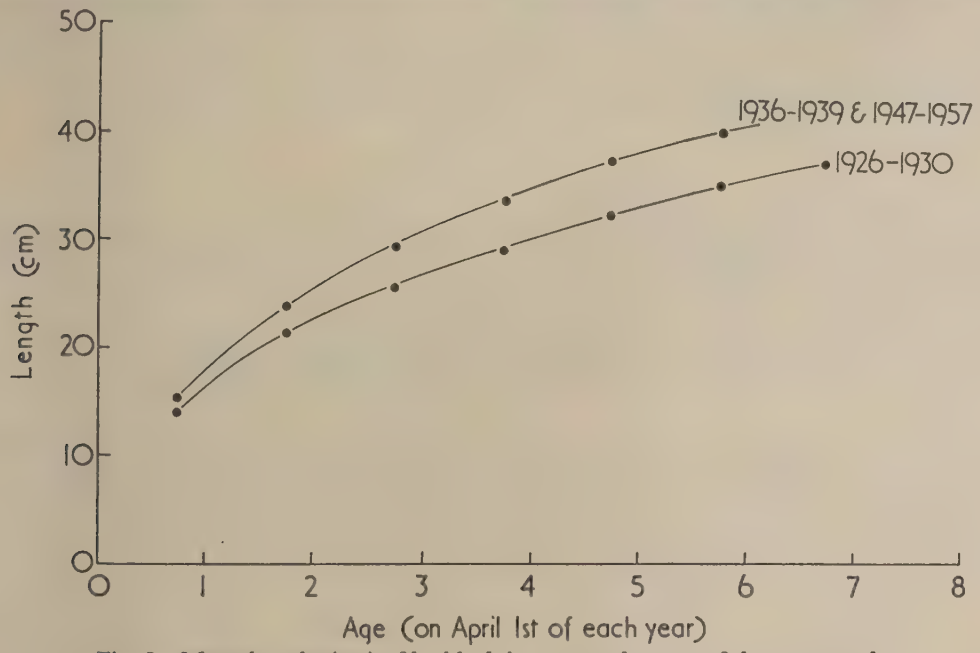

Fig. 8 Mean lengths (cm) of haddock in area 2, the area of slowest growth.

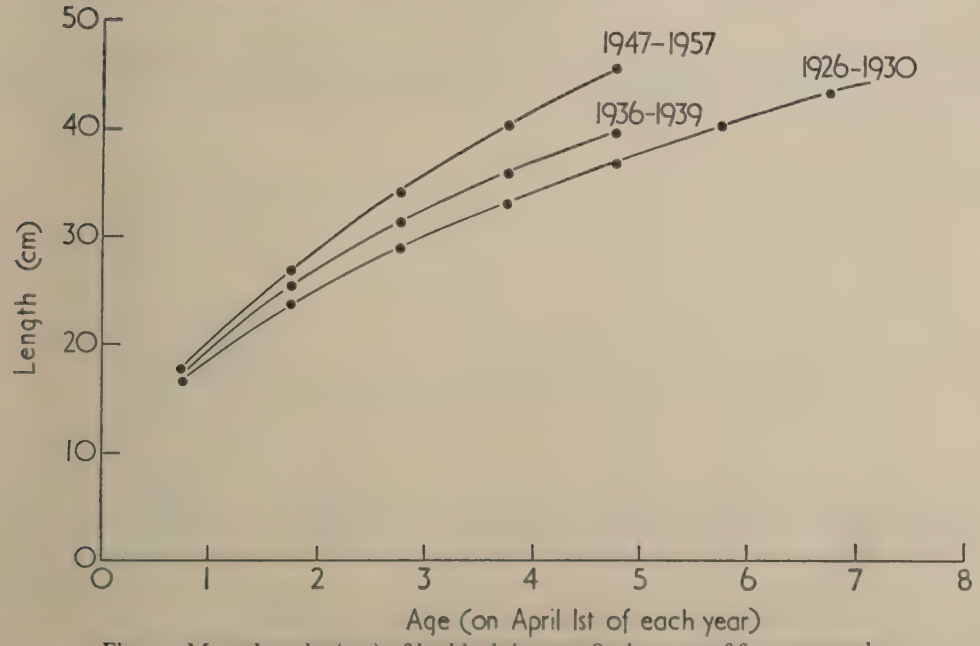

Fig. 9 Mean lengths (cm) of haddock in area 8, the area of fastest growth.

Growth Curves

The growth curves plotted in Figs. 8 and 9, using the mean values in Table IV plus some data for older fish, show the full range of growth as regards both time and area. As might have been expected, growth variation is greater in the area of fastest growth (area 8) than in the area of slowest growth (area 2).

For some purposes, curves such as those in Figs. 8 and 9 are adequate, but for investigation of the effect on the commercial fishery of changes in population equilibrium the mathematical techniques described by Beverton and Holt (1957) are frequently appropriate. To account for growth in the appropriate equations it is necessary to determine the parameters of the best-fitting "Bertalanffy curve", a method of growth interpretation that has also been described by Ford (1933) and Walford (1946). This curve takes the form:

$$L_t = L_\infty \ (1 - e^{-K(t-t_o)})$$

and the parameters that have to be estimated are L_∞, K and t_o.

This has been done, using the method described by the above authors, and the values obtained for the parameters are given in Table V.

TABLE V

ESTIMATES OF L_∞, K AND t_o FOR DIFFERENT PERIODS AND AREAS

Period \ Area	L_∞		K		t_o	
	2	8	2	8	2	8
1926–30	47·0	58·0	0·22	0·18	−0·85	−1·14
1936–39	51·4	48·2	0·25	0·33	−0·64	−0·55
1947–1957	46·5	68·1	0·30	0·20	−0·61	−0·74
mean	48·3	58·1	0·28	0·24	−0·70	−0·81

A somewhat surprising result is that although the 1936-1939 and 1947-1957 growth curves for area 2 are nearly identical, the parameters of the best fitting curves are very different. Values calculated from the theoretical curves are compared with the observed values in Table VI.

TABLE VI

SHOWING THE OBSERVED AND THEORETICAL VALUES (CM) OF TWO OF THE AREA 2 GROWTH CURVES

Age	Period			
	1936–1939		1947–1957	
	Theoretical	Observed	Theoretical	Observed
0·75	15·1	15·3	15·6	15·7
1·75	23·1	23·5	23·6	23·9
2·75	29·4	29·4	29·5	29·4
3·75	34·2	34·0	33·9	33·9
4·75	38·0	37·8	37·2	37·3
5·75	41·0	41·1*	—	—

*Value not included in Table IV

It appears that over a relatively limited age range, as instanced here, small differences in the length-data can lead to relatively large differences in the estimated values of L_∞ and K. Therefore, no ificance is attached to the differences between the estimates of these parameters in Table V, and in values for each area are given at the bottom of the table. It appears that the principal difference ween the area 2 and area 8 growth curves lies in the values of L_∞. Fish from area 2, the area of west growth, have a much lower value of L_∞ than those from the area of fast growth, area 8. The ues are:

Area 2	Area 8
$L_\infty = 48{\cdot}3$	$L_\infty = 58{\cdot}1$

FAROE HADDOCK

Estimates of the mean lengths of Faroe haddock are available from intermittent cruises by F.R.S. *Explorer* from the years 1923 to 1949. From 1950 to 1953 inclusive, sampling was by F.R.S. *Scotia*, and results of these cruises are published in *Annales Biologiques*, Vols. VII to X. From 1954 to 1957 there was no research ship sampling at Faroe but in November 1958 sampling was undertaken by the new *Explorer*. In addition to research ship records, an intensive series of measurements of Faroe haddock was carried out at Aberdeen Fish Market from 1950 onwards.

Subdivision into Areas

Fig. 10 shows the subdivision of the Faroe plateau for the analysis of the research ship samples. Treatment of the data was identical to that of the North Sea haddock. Mean lengths were determined for each age and mean differences were then determined between the lengths of haddock from the various areas.

Comparison of Areas

Table VII shows the mean differences between seven pairs of areas at three ages, 1·25, 2·25 and

TABLE VII

SHOWING THE MEAN DIFFERENCES (CM) BETWEEN LENGTHS OF HADDOCK TAKEN FROM DIFFERENT AREAS AT FAROE, 1923–1959

Area	Age		
	1·25	2·25	3·25
North West–North	3·6	1·9	2·8
North West–West	4·1	2·5	0·7
North–North East	0·4	1·9	2·6
North East–East	0·7	0·7	0·9
South–East	0·9	2·1	4·7
East–Sando Bank	1·0	3·8	4·6
Faroe Bank–South	1·2	5·0	12·0

5 years, corresponding to the ages of the fish during the summer months when the majority of *Explorer* and *Scotia* cruises were made. These data were combined to make up a table of lengths relative to those Sando Bank, the area of slowest growth (Table VIII). These results, which are also plotted in Figs. 11, and 13, show quite clearly that there is a strong east-west gradient in the mean sizes of the haddock, m the smallest on Sando Bank to larger fish to the west of the islands and to the largest fish on Faroe nk. Faroe Bank haddock when one year old are 3 cm larger than those on Sando Bank; at age two

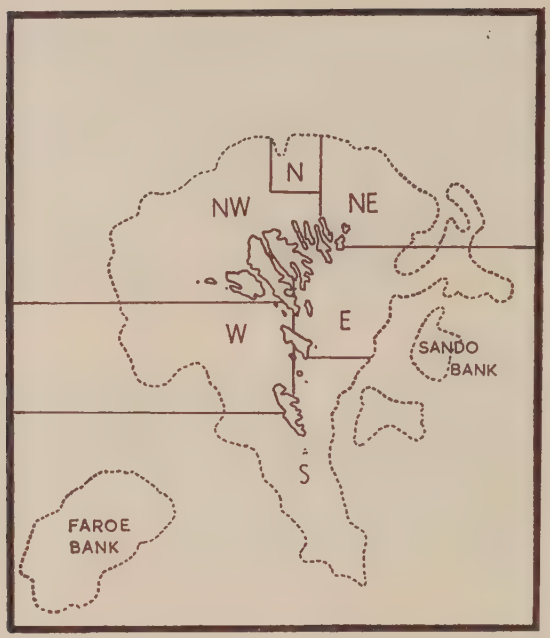

Fig. 10 Chart showing the subdivision of the Faroes into areas.

Fig. 11 Mean differences in the length (cm) of 1-year-old haddock in relation to the length on Sando Bank.

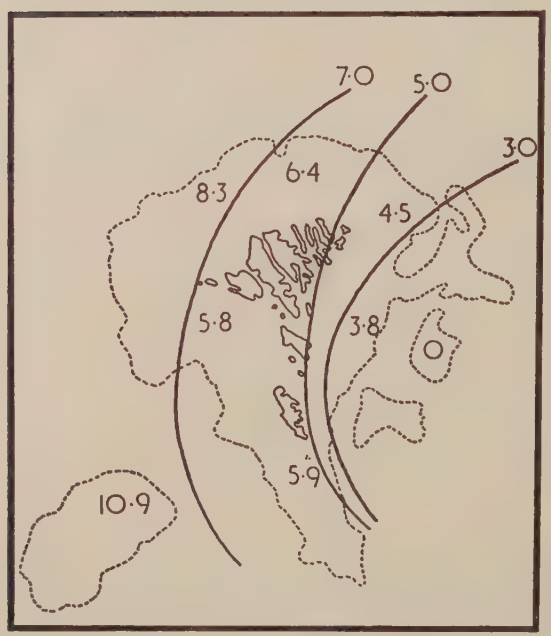

Fig. 12 Mean differences in the length (cm) of 2-years-old haddock in relation to the length on Sando Bank.

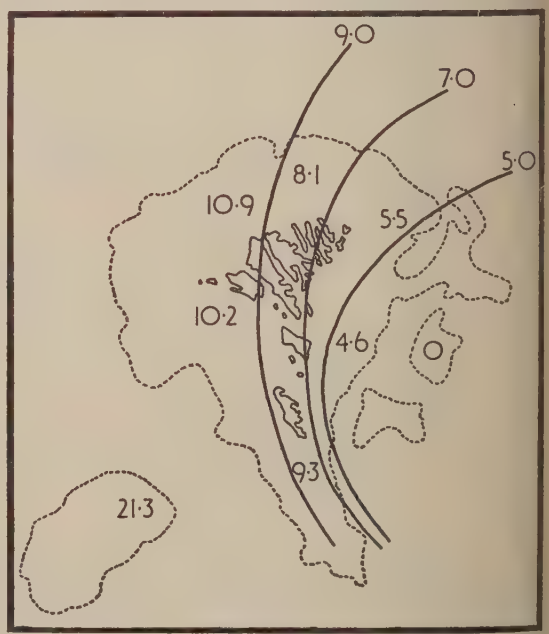

Fig. 13 Mean differences in the length (cm) of 3-years-old haddock in relation to the length on Sando Bank.

TABLE VIII

MEAN LENGTHS (CM) RELATIVE TO THOSE ON SANDO BANK

Area	Age		
	1·25	2·25	3·25
North West . . .	5·7	8·3	10·9
North . . .	2·1	6·4	8·1
North East . . .	1·7	4·5	5·5
East . . .	1·0	3·8	4·6
Sando Bank . .	0	0	0
South . . .	1·9	5·9	9·3
Faroe Bank . . .	3·1	10·9	21·3
West . . .	1·6	5·8	10·2

y are nearly 11 cm larger, and at age three they are over 20 cm larger. However, as there were very fish in many of the Faroe Bank samples, some of this very large difference may be due to sampling iations.

MPARISON OF YEARS

Table IX and Figs. 14, 15 and 16 show mean haddock lengths in successive years in three of the as. On Faroe Bank (Fig. 14) there were marked fluctuations in the mean lengths from 1929 to 1953 hout any well defined trend being evident. However, the 1959 mean lengths were considerably ow the average for the preceding period. In the north-western area (Fig. 15) there appears to have

TABLE IX

SHOWING HADDOCK MEAN LENGTHS (CM) IN DIFFERENT AREAS IN DIFFERENT YEARS

Year	Age								
	Faroe Bank			North West			East		
	1·25	2·25	3·25	1·25	2·25	3·25	1·25	2·25	3·25
1924 .	—	—	—	22·5	37·8	49·3	14·1	28·4	38·0
1929 .	19·7	33·6	47·0	22·5	36·5	42·5	16·5	31·8	38·4
1931 .	17·4	37·0	52·4	21·4	30·6	—	16·7	30·0	40·1
1933 .	22·3	—	—	22·4	33·8	47·0	16·6	28·8	36·3
1935 .	19·3	35·2	47·5	23·0	33·5	36·0	16·9	29·4	38·2
1936 .	18·0	32·9	—	23·1	36·5	42·0	17·8	29·7	44·0
1937 .	—	—	—	—	33·0	—	16·6	27·9	37·7
1938 .	20·4	—	54·5	24·7	33·3	40·5	—	—	—
1939 .	19·0	33·8	54·6	21·6	33·1	43·8	16·4	29·8	37·7
1947 .	22·5	39·5	46·1	21·4	31·9	40·6	16·2	26·9	36·1
1948 .	—	35·0	46·5	17·3	28·0	37·0	—	27·9	34·5
1949 .	—	—	—	—	—	—	15·9	29·8	—
1950 .	18·4	38·9	50·0	18·3	32·2	44·0	16·4	27·7	39·2
1951 .	19·8	35·1	56·0	20·3	32·8	42·1	15·9	25·9	35·2
1952 .	20·0	33·0	50·0	18·0	31·5	43·0	16·9	26·6	32·7
1953 .	22·0	—	—	18·6	33·2	41·5	16·9	30·4	—
1959 .	15·6	28·5	40·9	18·0	31·0	40·0	16·4	28·6	40·0

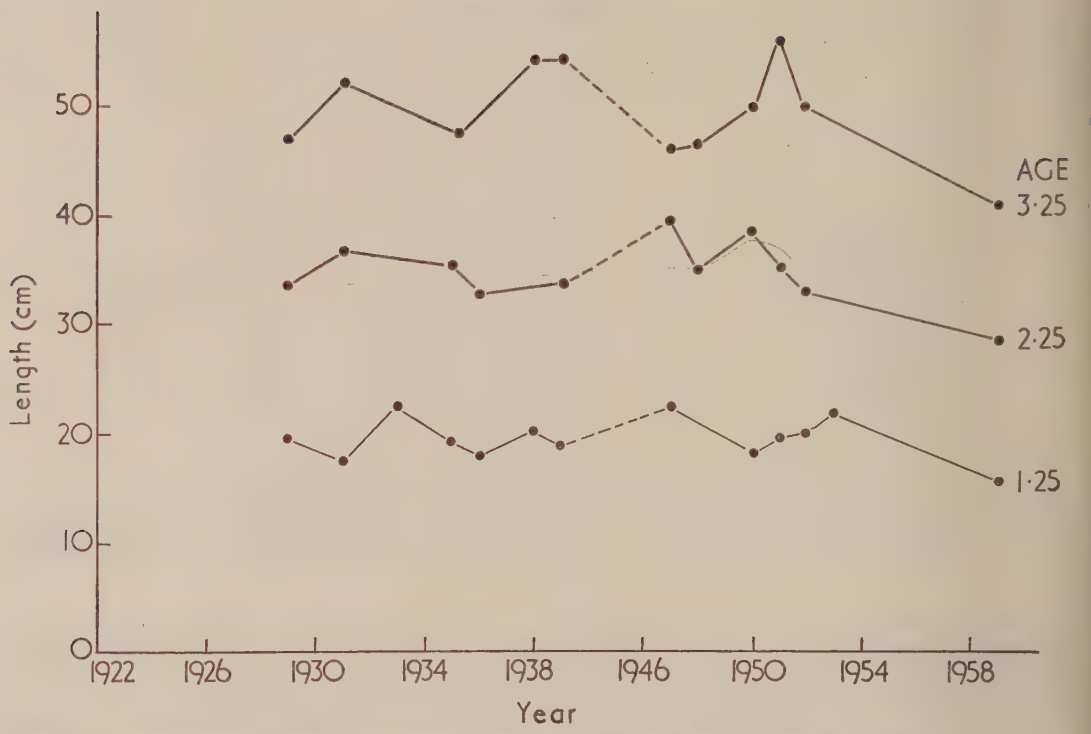

Fig. 14 Mean lengths (cm) of haddock on Faroe Bank (1929-1959). (Research ship data.)

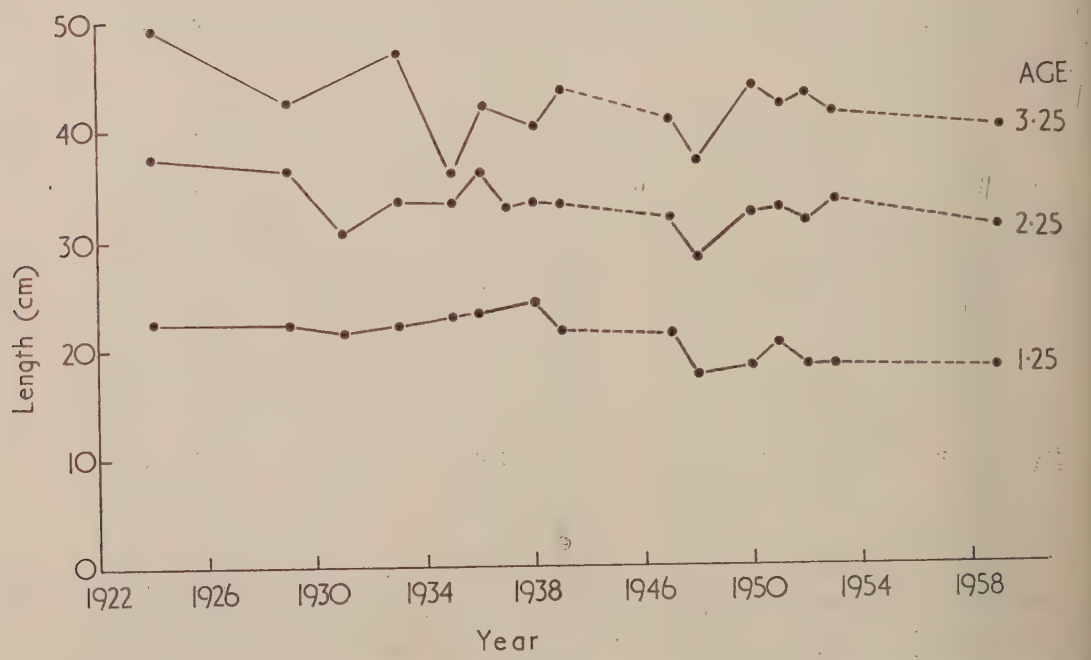

Fig. 15 Mean lengths (cm) of haddock from North West Faroes (1924-1959). (Research ship data.)

n a very slight downward trend in the mean lengths from 1924 to 1959. In the eastern area (Fig. 16) mean lengths were fairly constant from 1924 to 1959. The average values of the mean lengths in ble IX are shown in Table X and these provide useful estimates of the range of sizes of Faroe haddock to age three. Older fish were, on the whole, rather poorly represented in the research ship samples for reliable information on the mean lengths of these fish it is better to use market data.

TABLE X

SHOWING THE MEAN LENGTHS (CM) OF HADDOCK IN DIFFERENT PARTS OF FAROE, 1924–1959

Area	Age		
	1·25	2·25	3·25
Faroe Bank . .	19·6	34·8	49·6
North West . .	20·9	33·0	42·1
East . .	16·4	28·7	37·7

If the values in Table X are not wholly consistent with those in Table VIII, it is because of the erent method of computation used. Table X gives mean lengths of haddock in three areas, using all he available data. Table VIII shows mean differences between areas, using only those data that e strictly comparable as to time of sampling.

RKET DATA

Intensive sampling of Faroe haddock, providing data on the mean lengths of each age group in each nth, has been conducted at Aberdeen fish market since 1950. These data are summarised in Table XI,

TABLE XI

MEAN LENGTHS (CM) OF FAROE HADDOCK, 1950–1959

ge*	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	—	—	—	—	—	—	34·6	35·7	36·1	37·2	38·5	38·7
	39·4	39·8	40·1	39·8	40·2	41·7	42·0	43·4	44·6	46·0	46·6	47·1
	47·9	47·9	47·9	46·0	47·8	48·4	48·8	49·7	50·5	50·7	52·2	52·4
	52·7	53·0	53·2	52·3	53·8	54·3	54·5	55·4	56·3	56·6	57·4	57·1
	58·0	58·1	58·0	56·6	58·4	59·2	60·0	60·1	60·2	59·3	61·3	61·5
	62·0	62·0	62·1	61·6	62·3	63·5	62·6	65·3	64·2	64·7	64·2	64·7
	65·5	64·5	65·7	65·2	66·2	66·3	66·3	66·6	66·2	66·9	67·9	67·0
	68·3	67·0	67·5	68·1	68·3	68·0	68·2	68·9	70·0	69·3	69·5	69·8
	70·4	68·6	70·2	71·8	71·8	72·2	69·9	71·2	70·7	73·0	71·8	71·1
	69·7	72·4	74·4	72·8	73·6	70·5	73·7	71·7	68·8	74·1	72·9	69·4

*Ages at April

ere each monthly value represents the mean of ten values from ten separate years. They are also ated in Fig. 17, which shows the length—age relationship of Faroe haddock in the commercial

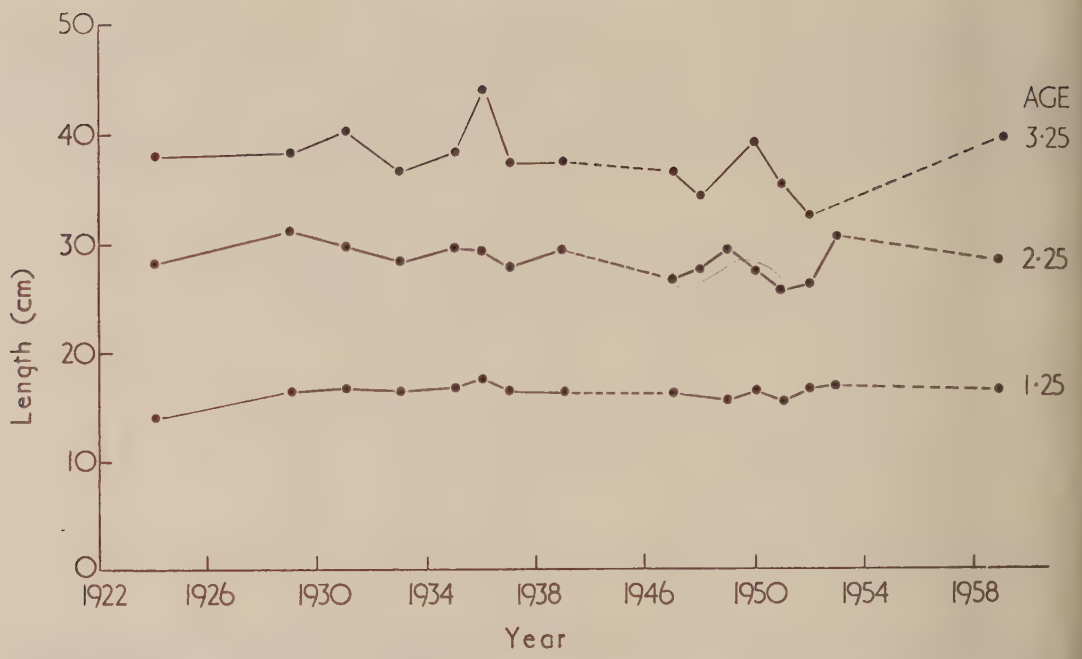

Fig. 16 Mean lengths (cm) of haddock from East Faroe (1924-1959). (Research ship data.)

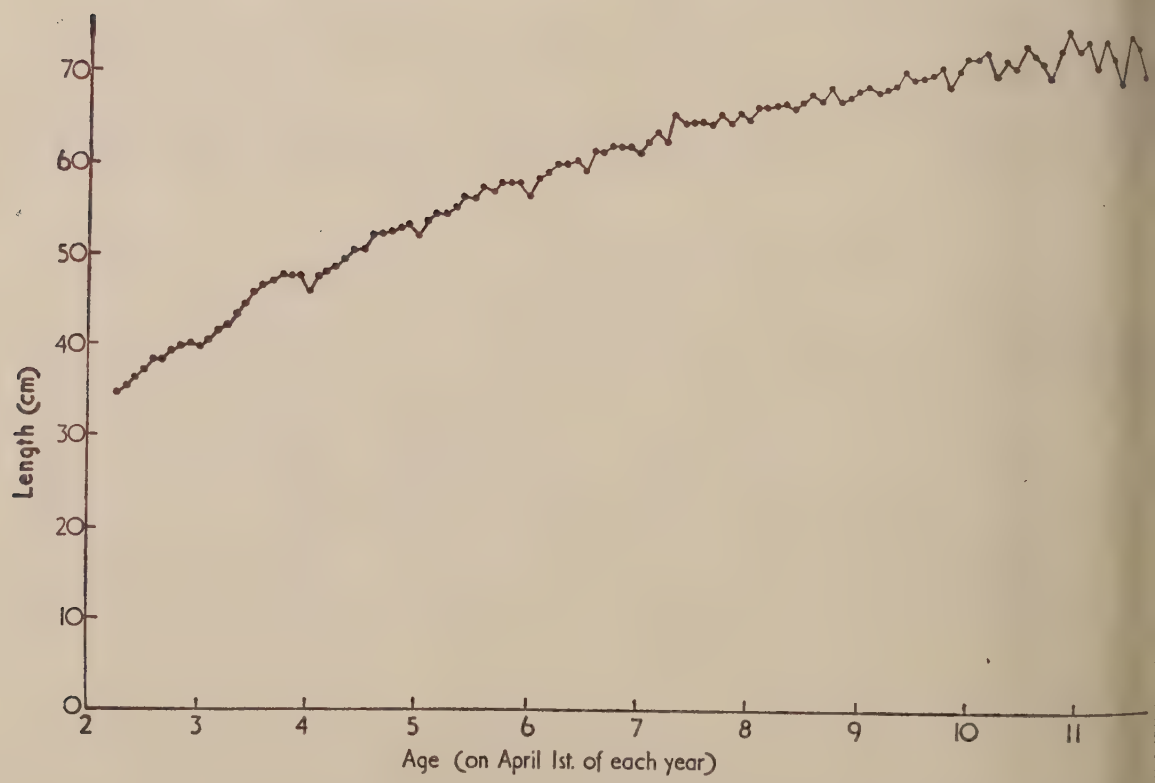

Fig. 17 Mean lengths (cm) of Faroe haddock from market data, 1950-1959.

dings from age 2¼ almost to age 12. The mean length at 3¼ years of age is about 40 cm, which lies ween the mean lengths for the eastern and north-western areas (Table X). This is in accordance with distribution of fishing by the Aberdeen fleet.

owth Curves

For investigation of the effect on the commercial fishery of changes in population equilibrium the a obtained from the commercial landings (Table XI) are more appropriate than the research ship a for determining the parameters of the best-fitting Bertalanffy curve. The parameters, derived from re as follows:

$$L_\infty = 77{\cdot}9 \qquad K = 0{\cdot}22 \qquad t_0 = -0{\cdot}47$$

ese parameters agree closely with those previously determined from research ship data (Parrish and es, 1953) which were:

$$L_\infty = 84 \qquad K = 0{\cdot}21 \qquad t_0 = 0$$

This growth curve has a higher value of L_∞ than those determined from North Sea data (Table V) similar values of K and t_0.

asonal Variations in Growth

The extensive market data, shown in Fig. 17, clearly illustrate the seasonal nature of the growth of oe haddock. In each year growth is most rapid during the summer and autumn, from May to cember. During January, February and March there is very little growth. An interesting feature of data is the apparent decrease in the size of each age-group in April, a phenomenon which has occurred ly consistently throughout the ten years in which the data were collected. From the information ilable on the distribution of the fishery in this and other months, this phenomenon cannot be explained erms of fleet distribution. Its cause is uncertain, although it is noteworthy that it coincides with the wning period. A possible explanation might lie in a change in the behaviour of the fish, resulting, in ril, either in the smaller fish within each age group becoming easier to capture or in the larger fish oming more difficult to capture.

SEX DIFFERENCES IN LENGTH

Sex differences in length were determined by using research ship data collected in the North Sea l at Faroe during 1950 and 1951. These show that female haddock are significantly larger than male ddock of the same age, and a summary of these results is given in Table XII.

TABLE XII

THE MEAN DIFFERENCES (CM) IN LENGTH BETWEEN FEMALE AND MALE HADDOCK AT SUCCESSIVE AGES IN 1950 AND 1951

Age	Area	
	North Sea	Faroe
1·25	0·16	0·02
2·25	0·78	0·25
3·25	1·13	0·59
4·25	2·08	1·11

SUMMARY

O-group haddock throughout the northern North Sea show comparatively little variation in mean size. Thereafter, several areas of different growth rate can be distinguished, the slowest growers being found in the deep northern North Sea basin and the fastest growers off the Scottish east coast and in the region of the Great Fisher Bank. By the time haddock are five years old the fish in the areas of fast growth tend to be about 5 cm larger than those in the area of slowest growth.

Comparison of haddock sizes in different years show that from 1926 to 1930 there was little variation in growth in areas of either fast or slow growth. After 1930, however, there was a tendency for mean sizes to increase in both fast and slow growing areas, especially amongst the older fish. After the war haddock in the areas of fast growth tended to be larger than before but there was no noticeable difference in the sizes of haddock from the areas of slow growth.

Bertalanffy curves were fitted to the growth data from the various areas. The values of the parameters were:

$$K = 0{\cdot}26 \qquad t_o = -0{\cdot}76 \qquad L_\infty = 48{\cdot}3 \text{ in the area of slowest growth}$$
$$L_\infty = 58{\cdot}1 \text{ in the area of fastest growth}$$

An investigation of the growth of haddock in the Faroes area was carried out along similar lines. Very marked variations in growth rate were found between different areas, the slowest-growing fish being found on Sando Bank and the fastest growers on Faroe Bank. By the time haddock are three years old Faroe Bank fish appear to be about 20 cm larger than those on Sando Bank, although, since this difference is based on some rather small samples, some of it may be due to sampling variation.

Comparison of sizes in different years showed no marked trend in the mean lengths from 1924 to 1959.

A Bertalanffy growth curve was fitted to the available data and gave the following values of the parameters:

$$K = 0{\cdot}22 \qquad t_o = -0{\cdot}47 \qquad L_\infty = 77{\cdot}9$$

Comparison of mean sizes in different months showed that there is a marked seasonal variation in growth which is most rapid from May to December and least marked from January to March.

Extensive data collected during 1950 and 1951 were examined for sex differences in growth. These show that female haddock are significantly larger than male haddock of the same age.

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